CLAIMS

What is claimed is:

1. An apparatus cooling a metallic workpiece, the apparatus comprising:

a support surface for supporting the workpiece in an operative position;

a source of a cooling gas and an additional coolant, said cooling gas comprising one or more constituent gases that are gases at ambient conditions; and said additional coolant comprising one or more constituents that are liquid at ambient conditions; and

a conduit system directing the cooling gas and additional coolant from the source and having a plurality of outlets positioned to discharge a mixture of the cooling gas and the additional coolant to impinge the workpiece in the operative position.

2. The apparatus of claim 1 wherein:

the source comprises a first source of the cooling gas and a second source of the additional coolant.

3. The apparatus of claim 1 wherein:

said additional coolant one or more constituents include water;

said water in said mixture has a mass flow rate of 5-20% of a mass flow rate of said cooling gas.

4. The apparatus of claim 1 wherein:

a major portion of said water in said mixture is steam.

5. The apparatus of claim 1 wherein:

a major portion of said water in said mixture is in droplet form.

6. The apparatus of claim 1 wherein:

a said support surface is provided by surface portions of a plurality of vertically-extending rods.

7. The apparatus of claim 1 further comprising:

a motor;

a linkage coupling the motor to at least one of the support surface the conduit system and driven by the motor to produce oscillation of the workpiece relative to the outlets.

8. The apparatus of claim 1 said apparatus impingement cools said workpiece.

9. An apparatus for cooling a metallic workpiece, said workpiece having a cross-section including a first portion that is substantially thicker and more massive than a second portion that is relatively thinner and less massive, said apparatus comprising:

a fixture for supporting the workpiece;

a source of a mixture of a compressed cooling gas containing liquid droplets for quenching the work piece; and

a set of tubes for delivering and directing the compressed cooling gas onto said workpiece for cooling, so that said compressed cooling gas flows onto said first portion that is substantially thicker and more massive and away from said second portion that is relatively thinner and less massive.

10. The apparatus of claim 9 wherein the source includes:

at least a first gas source of said cooling gas; and

means for adding said liquid droplets to the cooling gas along a gas flowpath between the first gas source and the workpiece.

11. The apparatus of claim 9 further comprising means for providing relative movement of the forging and tubes during the cooling.

12. The apparatus of claim 9 said apparatus impingement cools said workpiece.

13. A method for cooling a forging, the method comprising:

mixing at least a first fluid that is a gas at ambient conditions with at least a second fluid that is a liquid at ambient conditions to form a mixture wherein a mass flow of the at least a second fluid is 2-20 percent of a mass flow of the at least a first fluid; and

directing the mixture to impinge on a surface of the forging so as to cool the forging.

14. The method of claim 13 wherein the mixing forms the mixture with said second fluid in major part as a gas.

15. The method of claim 13 wherein the mixing forms the mixture with said second fluid

in major part as a liquid.

16. The method of claim 13 wherein the mixing forms the mixture comprising:

air essentially as said first fluid; and

water essentially as said second fluid.

17. The method of claim 13 wherein the mixing forms the mixture consisting essentially of:

air as said first fluid; and

water as said second fluid.

18. The method of claim 13 wherein the directing comprises:

directing a first portion of the mixture to impinge on first portions of the surface; and

directing a second portion of the mixture to impinge on second portions of the surface, substantially opposite said first portions.

19. The method of claim 13 performed on a turbine engine disk as said forging.

20. The method of claim 13 performed on a nickel- or cobalt-based superalloy article as said forging.

21. The method of claim 13 further comprising moving at least one of the forging and outlet flows of the mixture during the cooling.

22. The method of claim 21 wherein the oscillating comprises reciprocal rotation about an axis at an amplitude of at least +/- 4° and a frequency of less than 2.0 Hz.

23. A method for heat treating a forging comprising:

mixing at least a first fluid that is a gas at ambient conditions with at least a second fluid that is a liquid at ambient conditions to form a mixture wherein a mass content of the second fluid is 2-20 weight percent of a mass content of the first fluid;

directing the mixture to impinge on a surface of the forging so as to cool the forging; and

moving the forging relative to an impinging flow of said mixture.

24. The method of claim 23 performed on a nickel- or cobalt-based superalloy forging as said forging.

25. The method of claim 23 wherein the moving comprises oscillating the forging.

26. An apparatus for cooling a heat-treated metallic workpiece, said apparatus comprising:

a fixture for supporting the workpiece;

a source of a cooling gas for quenching the workpiece;

a conduit system delivering the cooling gas from the source and directing the cooling gas onto the workpiece so as to cool the workpiece; and

means for moving the workpiece relative to the conduit system during the cooling of the workpiece.

27. The apparatus of claim 26 wherein the means for moving produces oscillation of the workpiece relative to the conduit system.

28. The apparatus of claim 26 wherein the means for moving comprises:

an electric motor; and

a mechanical linkage coupling the motor to the fixture so that continuous rotation of shaft of the motor in a first direction produces oscillation of the fixture.